

## THE SEX RATIO IN NESTLING EASTERN RED-WINGS<sup>1</sup>

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A NUMBER of studies have been made of sex ratios in birds, and the information available on the subject has been recently summarized by Mayr (1939). He classifies sex ratios as follows: "The primary sex ratio relates to the proportion of the sexes at the time of fertilization, the secondary sex ratio at the time of birth and the tertiary sex ratio during adult life." On the basis of genetics the expected ratio is 50:50 but as shown by Mayr, departures from this are not rare among birds, especially in the tertiary ratio. Of the three ratios the primary is probably of the greatest interest because of its bearing on problems relating to the mechanism of sex determination as well as on those involving details of life history. The existence of an unbalanced primary ratio, if definitely established, would present a problem of fundamental biologic interest. It is also evident that many interesting peculiarities of life history, such as polygamy, the development of social habits, and brood parasitism may be linked with unbalanced sex ratios.

The Red-wing (*Agelaius phoeniceus*) offers a number of advantages as the subject of a study of sex ratios. The species shows striking sexual dimorphism, the differences between the sexes involving size as well as color. It is often highly gregarious in nesting, an important practical point, since studies of this sort require an abundance of data. Lastly, it belongs to a group, the family *Icteridae*, in which unbalanced sex ratios and interesting life history patterns have frequently been found. For example, in Wagler's Oropendola (*Zarhynchus wagleri*) Chapman (1928, p. 135) observed an excess of females and a condition which he termed "limited monogamy," in which the sexual bond was of short duration and each male had several mates in the course of the breeding season. A surplus of females has also been reported by McIlhenny (1940, p. 88) in the Boat-tailed Grackle (*Cassidix mexicanus major*), a species in which there is no pairing and the mating is promiscuous. Friedmann (1929, pp. 77, 173) presents some evidence which indicates that there is an excess of males in the Common Cowbird (*Molothrus ater ater*), which is a brood parasite. Lack and Emlen (1939) found that the Tricolored Red-wing (*Agelaius tricolor*), which nests in large colonies, is polygynous or promiscuous, and that the sex ratio is strongly unbalanced among the adults, with about 47 males for each 100 females.

The Eastern Red-wing (*Agelaius phoeniceus phoeniceus*) exhibits much of the behavior of a territorial species, although there is a strong gregarious tendency and the territories may be very small. Thus the males arrive first, display and sing at rather definite stations, in the

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neighborhood of which other males are attacked and driven off. Most of the feeding, however, is done away from the territory. Due to this habit of feeding elsewhere and to the close approximation of the individual territories, it is difficult to determine the sex ratio of the adults and the exact relations that exist between the sexes. Allen (1914, pp. 90-92) records instances of both polygyny and polyandry but apparently believes that the normal relation is one of monogamy. My own observations, in cases where two nests were located in close proximity, have given me the impression that monogamy is the prevailing condition. In the extensive literature, however, one encounters quite different opinions. For example, Roberts (1932, Vol 2, p 306) states that the Giant Red-wing (*Agelaius phoeniceus arctolegus*) is usually polygynous, and Linsdale (1938, pp. 128, 140) found polygyny in small colonies of the Nevada Red-wing (*A. p. nevadensis*). Surprisingly, McIlhenny (1940) says that the Gulf Coast Red-wing (*A. p. littoralis*) is monogamous despite the fact that there is a large surplus of males in the population. The explanation of this apparent anomaly may be found in a statement by the same author that the females breed in their first spring after hatching while the males do not breed until their second year.

In cases where the sex ratio is known to be unbalanced among adults it becomes a matter of no little interest to determine the ratio in the young. This has been attempted in a very few species, the Red-wing among others. McIlhenny (1940) gives a ratio of 3.3 males per 1 female in a large number (420) of Gulf Coast Red-wings, using only data from nests in which the full complement of three eggs hatched. This constitutes a primary ratio in the definition of Mayr (1939). Unfortunately the methods used in sexing the nestlings are not described. Herman (1938) has published ratios for the Eastern Red-wing, based on rather small samples of birds that were trapped and sexed sometime after having been banded in the nest. There were recovered 29 males and 13 females, and the totals for those cases in which complete sets of siblings were recovered were 14 males and 6 females.

Since the Red-wing exhibits a marked sexual dimorphism it might be expected that it would be possible to distinguish the sexes at an early age. Packard (1936) was able to sex individuals in the fully developed juvenal plumage, but not in the nestling stage. In my own work at Put-in-Bay, Ohio, during the summer of 1939 I was unable to find any plumage character or other external mark by which the nestlings might be sexed. In reply to an inquiry from me Mr. E. A. McIlhenny, Avery Island, Louisiana wrote as follows: "The sex of the Gulf Coast Red-wing nestlings can be told with certainty at any time after the fifth day from external appearances of the bill, torso, and general body size." The present paper reports the results of an attempt to find a satisfactory method of distinguishing the sexes of nestlings, together with a brief analysis, by a simple statistical method, of the sex ratios that were found in the nestlings of a single colony.

## METHODS OF STUDY

The area in which the present study was made consists of a cat-tail (*Typha latifolia*) marsh, about ten acres in extent, located at the north-eastern corner of Indian Lake, Logan County, Ohio. It is the site of a refuge maintained by the Ohio Division of Conservation. The water in the marsh is sufficiently shallow so that an observer equipped with sporting boots is able to gain access to all but a very few of the Red-wing nests in the area. Regular field work was begun here on June 18, 1940. Nesting activities had begun some time before this date, and it is known that a few young had already been fledged.

Each nest that was found was marked with a numbered cloth tag, and daily visits were made to it sometime between 8:00 A.M. and 1:00 P.M., with a few exceptions due to weather conditions or other circumstances beyond control. For each nest a separate record was kept, showing number of eggs or young, date of hatching, weights and measurements of young. As soon as a newly hatched bird was found in the nest it was marked by tying a colored thread around the tarsus. During the first few days of nest life these threads frequently slipped off. Since it rarely occurred that more than one thread was lost in a given nest few records were lost due to this cause. At the age of four or five days it was found necessary to replace these threads due to the growth of the nestlings.

The age of the nestlings was recorded in terms of days. Each nest was visited at approximately the same hour from day to day, and this method obviously involved an error of almost one day in the recorded age. Efforts were made to correct this error by close observation as to the condition of the bird when it was first found hatched. Wet or moist down was accepted as evidence that hatching had taken place shortly before the nest was visited, and in such cases the birds were not considered one day old until one day after the thread had been attached to the tarsus. The presence of dry, fluffy down together with relatively large bill and tarsal measurements was considered as evidence that the bird in question had hatched sometime the previous day but following my visit. In such cases birds were recorded as one day old. Pipped eggs were also recorded when found, and this was often found useful in helping to estimate the time of hatching.

A few nestlings were dissected in order to determine the sex. At the time of hatching the ovary is a flat, oval-shaped organ about 1.5 millimeters in length. At this age the testes are typically shaped and about .8 millimeters in length. The gonads do not grow at a rate proportional to the rest of the body, but at ten days of age have approximately doubled the dimensions at hatching.

The weights of the nestlings were taken with spring scales having a capacity of 250 grams, marked in 10 gram divisions. The division marks are about 2.5 millimeters apart and estimates were made to the

gram. This permits a large error of measurement, but with practice a fair degree of accuracy is possible. A check was made by taking a few weights with both the spring scales and platform balances. Of ten weights used there was no case in which the two readings varied more than one gram. The spring scales were used because of the difficulty of carrying the more accurate platform balances into the marsh. A small piece of fish line was used to suspend the birds from the scales. It was looped around the base of the wing, or in the case of very young birds, around the wing and neck. Insofar as could be observed no injury was done to the birds, which usually remained motionless while being weighed unless they were old enough to attempt flight.

Measurements of the culmen and tarsus were made with a Vernier caliper. These measurements are very easily made but there is some danger of injury to the young nestlings unless care is exercised in removing the locked caliper from the leg. After many measurements of the culmen had been made it was decided that the differences were too small to be of any great value in distinguishing the sexes and this measurement was discontinued.

Since the complete record of each nest was carried into the field it was possible to determine whether or not the individual birds were gaining weight from day to day. After observing a few birds that had lost weight from the previous day, I noted that these individuals generally died. Later, in order to avoid the loss of valuable records, nestlings which had lost weight from the previous day were removed from the nest and dissections were made to determine their sex. Although as a general practice weights and measurements were taken on all birds, there were unavoidable exceptions to this routine, and consequently the data on weights do not relate to precisely the same numbers and individuals as the data concerning tarsal measurements. It was my privilege to measure and dissect some additional nestlings collected by Mr. Otis Allen in the neighborhood of the Stone Laboratory, Put-in-Bay, Ohio. Data from these birds have been used to supplement my own notes in studying the relation of tarsal length to sex. The material on sex ratio applies exclusively to the Indian Lake colony.

#### WEIGHTS OF NESTLINGS

At hatching the average weight of the Red-wing nestling is approximately five grams. A histogram showing the weights of one day old birds indicates a normal distribution. Although the range increases greatly during the second and third days, it is not until the fourth that a bimodal distribution becomes clearly apparent (Fig. 1). At the fifth day there is a break definitely separating a light from a heavy group, and this break remains in the graphs for older nestlings, increasing in extent. In the ten day old birds there is a difference of six grams between the heaviest bird in the light group and the lightest individual



of the heavy group. From the eighth day on sixteen birds of known weight were sexed by dissection, and in each case the females fell into the light and the males into the heavy group. It thus seems quite apparent that there is complete differentiation between the sexes with regard to weight during nest life.

In order to trace the development of this dimorphism twenty-five individuals of each sex were selected and their daily weights during nest life were plotted (Fig. 2). The graph offers convincing evidence

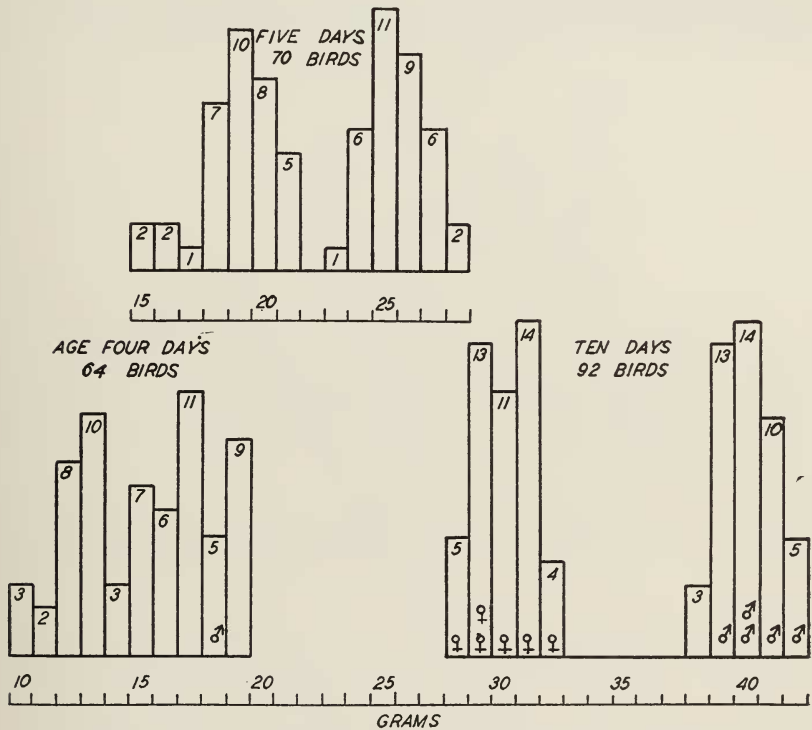


Figure 1. Weights of nestling Red-wings at four, five, and ten days of age. Frequency indicated by figure at top of each column. Each sex symbol represents an individual sexed by dissection.

that the difference in weight between the sexes begins early in the nestling stage. Due to the crude method of weighing used, it did not prove feasible to obtain statistically satisfactory means from these data. It is evident, however, that these samples show no overlap in weights after the fourth day. Since in this study nests were visited at daily intervals, there is a possible error in the method of aging the young which may amount to nearly a day. It can be seen from the data presented graphically in Figure 2 that this possible source of error in aging can

involve error in sexing until the eighth day, since some seven day old males weigh as little as the lightest of the eight day old females. On the ninth day the gap between the two groups is large enough to overcome this source of error in sexing. With more accurately aged nestlings and more refined methods of weighing doubtless the sexes could be distinguished at an earlier age.

#### TARSAL LENGTHS OF NESTLINGS

The data on tarsal length were treated in much the same way as those on weights and they show the same general trends (Fig. 3). A

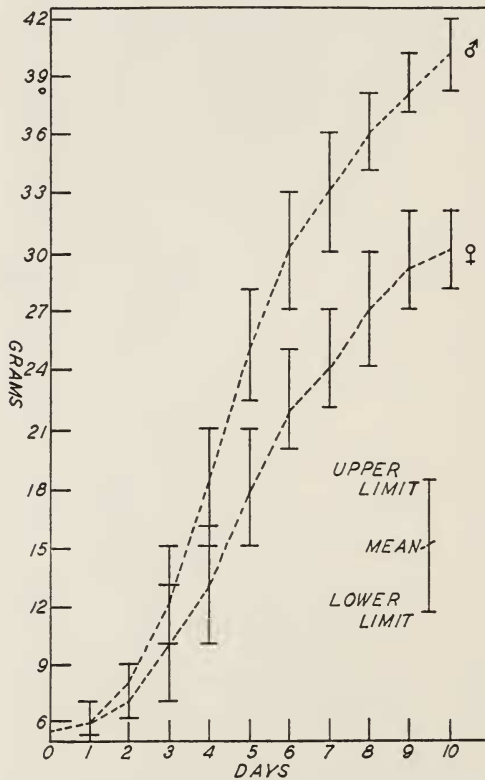


Figure 2. Daily weights of 25 male and 25 female Red-wing nestlings whose identity was known throughout the nestling period. The extent of individual variation is indicated by the length of the vertical bars. The broken line connects the means.

bimodal distribution is indicated at three days, but there is no break between the large and small groups until the eighth day. Even in the ten day old birds the gap is small. That the division into two groups

is associated with sex seems certain, since in a total of fourteen individuals of eight days or older that were sexed by dissection all of the females had tarsal lengths within the range of the small group for the corresponding day, while the tarsal lengths of the males were consistently those of the large group.

These data are based on a more accurate method of measurement than was used in weighing, and are subject to statistical analysis. At ten days the gap between the male and female groups is so small that one might suspect that an overlap would be found in a larger sample. The probability of this can easily be determined to a degree sufficiently accurate for practical purposes. The mean length for the ten day old



Figure 3. Tarsal lengths of nestling Red-wings at three, eight, and ten days of age. Frequency indicated by figure at top of each column. Each sex symbol represents an individual sexed by dissection.

females is 25.68 millimeters and the standard deviation is .66. For the males the mean is 29.15 and the standard deviation .51. Since in a normal distribution three times the standard deviation taken on either side of the mean includes about 99.75 per cent of the individuals (Simpson and Roe, 1939, p. 118), it follows that the probable limits of tarsal lengths in this population are: for the females, 23.70 to 27.66; for the males 27.62 to 30.68 mm. A negligible amount of overlap is indicated which would affect the accuracy of sexing by this criterion in less than one case in a hundred. It happens that in my data those individuals with tarsal measurements close to this theoretical area of overlap were among those sexed by dissection.

The range of individual variation is sufficiently great that an error in aging might involve an error in sexing even after the ninth day, since some nine day males have tarsi as short as some ten day females. Due to the larger hiatus between the sexes it seems evident that weights offer a more reliable criterion of sex than tarsal measurements.

The relative ease of securing the latter tends to overcome the advantage of using weights, and if the age of the nestlings is accurately known there would seem to be no appreciable error in sexing these nestling Red-wings on the basis of their tarsal length.

#### SEX RATIO

In his review of sex ratios among birds Mayr (1939) states: "The primary sex ratio of birds is easily obtained because it equals the secondary sex ratio in all those broods where the complete clutch of eggs hatches." In the Eastern Red-wing, however, and in other birds where there is variation in the egg complement it is not easy to decide what constitutes a "complete" clutch. According to Allen (1914, p. 99): "The usual complement is three or four, the one number being as common as the other. Not infrequently five eggs, and rarely six, are found in a nest." In practice however it may occur that an egg is laid outside of the nest or taken by a predator. Departures from the normal complement due to these causes are not easily detected, and in a single sample it is quite possible that such losses might result in a difference between the sex ratios at the time of fertilization and at hatching, that is between the "primary" and "secondary" ratios of Mayr.

In the 67 nests used for this study there were 7 with two eggs, 40 with three eggs, and 20 with four eggs, making a total of 214 eggs and an average of 3.19 per nest. Data concerning the fate of these are summarized in Table 1. In attempting to arrive at a primary sex

TABLE 1  
MORTALITY IN 67 NESTS CONTAINING 214 EGGS

	Number	Percentage
Eggs stolen or deserted .....	32	15
Infertile or died in embryo .....	26	12
Hatched but not fledged .....	51	24
Fledged .....	105	49

ratio it seems advisable to eliminate from consideration all nests with two eggs, since it is doubtful that they represent complete sets. Those nests for which records are incomplete, due to presence of sterile eggs, loss of eggs to predators, or loss of young before they reached an age at which sexing was possible, must also be eliminated. My records include complete histories of 35 nests in which there were three or four eggs, all of which hatched. Since undetected losses may have occurred from some of these nests the sex ratio obtained from my records is not to be regarded as a primary ratio but only as the closest possible approximation. The sex ratios in these 35 nests are presented in Table 2. A conspicuous random variation in individual nest combinations is apparent. The ratio of the entire group is 57 males to 62 females (47.9 per cent males, 52.1 per cent females; or 92 males per 100 females). Is the slight excess of females in this sample necessarily in-



dicative of an unbalanced ratio in the population? If we apply the Chi-square method (Snedecor, 1938, Chap. 1) and test the 57:62 ratio against the expected 50:50 the resulting value of Chi-square be-

TABLE 2  
SEX RATIO IN 35 NESTS WITH 3 OR 4 YOUNG

Nest ratio	Frequency	Males	Females
4 to 0	1	4	0
3 to 1	4	12	4
2 to 1	9	18	9
2 to 2	8	16	16
1 to 2	7	7	14
0 to 3	5	0	15
0 to 4	1	0	4
Total	35	57	62

comes .210, far below the conventional level of significance. The conclusion is that the 57:62 ratio could easily occur as a random sample in a population with a true ratio of 50:50.

The ratios published by McIlhenny (1940) for the Gulf Coast Red-wing are so widely at variance with the ratio found in the Indian Lake birds that it is almost inconceivable that the populations in the two localities are homogeneous with regard to sex ratio. Granting the accuracy of the method of sexing of the Louisiana birds, one can only conclude that conditions as regards sex ratio may be extraordinarily variable among the geographic races of a single species. A comparison with the ratios found by Herman (1938) again yields a striking discrepancy, since he states that in his birds there was a large excess of males (more than two males for one female). In this case a point of technique must be raised. As stated above, Herman's ratios were derived from birds which were banded as nestlings but not sexed until they were trapped sometimes after leaving the nest. There are reasons to question that this method is valid to disclose the sex ratio existing in a group of nestlings. First, the sex ratio in the population at the time of trapping will influence the returns. A surplus of males might result from a higher death rate among the females in the interval between banding and trapping. Another factor which might cause an apparent surplus of males is a greater susceptibility to traps on the part of the males. The existence of either of these hypothetical conditions might affect not only the total returns but also the sibling returns. There is ample evidence in Table 2 of variation in sex ratios among sets of siblings. It seems quite clear that a higher death rate among the females would favor the chance of the return of those sets of siblings which are predominantly males, and a difference in behavior between the sexes which resulted in males entering traps more readily than the females would have the same effect.

During the period from June 18 to July 22 there was fledged from the 67 nests under observation a total of 105 birds. It is possible that this number might have been slightly larger had I not removed certain nestlings which had lost weight. My experience, however, leads me to believe that such birds rarely survive. In arriving at a sex ratio among fledged birds all nests were included from which any birds of known sex were fledged. Of the 105 fledged young the sex was determined in 94 cases, either by weight or by tarsal length. The sex ratio among these birds was exactly balanced, with 47 males and 47 females.

Among the 51 casualties during nest life many losses occurred before the nestlings had reached an age at which sex could be determined by weights or tarsal measurements, and the dead nestlings, which could have been sexed by dissection, were seldom found. The proportion of this loss that was due to predators is not known. Of the 51 young which did not survive to be fledged the sex is known in only 21 cases. Of these 9 were males and 12 females. This suggests that the death rate may have been higher among the females. Testing the 9:12 ratio against the hypothetical even ratio by the Chi-square method yields a value of .428. Since this is far below the level of significance we conclude that the existence of a different death rate between the sexes cannot be established by these figures.

In general the results of the present inquiry fail to demonstrate any marked departure from a balanced sex ratio. It is by no means certain that sex ratios will prove to be the same in other localities within the range of the Red-wing, nor even at Indian Lake in other years. Before general valid conclusions can be reached further studies must be made. Ideally such studies should cover an entire nesting season. It is believed that the technique of sexing the young used in the present investigation should be of value to other workers. Due to the geographic variation in size within the species it will probably be necessary to determine the actual limits of the weights and measurements of the sexes independently in other localities.

#### SUMMARY

In a study of nestling Eastern Red-wings made at Indian Lake, Ohio from June 18 to July 22 it was found that the young could be sexed by dissection at any time after hatching.

With the age of nestlings known to the nearest day it proved possible to distinguish between the sexes by means of weights after the fifth day, and by means of tarsal lengths after the eighth day.

The following sex ratios were found:

Among 119 young, representing the full egg complements of 35 nests, 57 males: 62 females.

Among 94 young which were successfully fledged, 47 males: 47 females.

Among 21 young which died during the nesting period, 9 males: 12 females.

The apparent deviation of the first and third of these ratios from the expected 50:50 could easily be due to random variation in sampling.

ACKNOWLEDGMENTS

I am indebted to Dr. Charles F. Walker of the Stone Laboratory of the Ohio State University at Put-in-Bay, Ohio for advice during the course of the investigation, and for assistance in the preparation of this paper; to Mr. Otis Allen for the use of preserved specimens; and to Mr. E. A. McIlhenny for his courteous reply to my inquiry as to his methods of sexing young Red-wings.

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